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ABSTRACT

Males have consistently been noted to perform better than females on Piagetian horizontality and verticality tasks. To examine whether females are less competent than males or whether mediating variables influence females' performance, 42 male and 42 female college students performed horizontality and verticality tasks. Subjects also rated their expectancies for both success and failure on the tasks and their perceptions about the scientific/mathematical nature of the tasks. An analysis of the results showed that females performed more poorly than male subjects on both tasks and had lower expectancies for successful task performance. Individuals with lower expectancies for success tended to have lower task scores. When expectancies about performance were partialled out, the amount of horizontality variance explained by gender was reduced by 60% and the sex difference in performance was not significant. For verticality, while the sex difference remained significant with expectancies partialled out, there was a 40% reduction in the proportion of variance explained by gender. These findings support the view that expectancies mediate performance on these tasks. The sex difference in expectancies could not be accounted for by perceptions of the tasks as scientific/mathematical. Nor were ratings of the tasks as scientific related to actual task achievement. Performance on the horizontality and verticality tasks was moderately correlated for both sexes, indicating that the two concepts do tap the same underlying Euclidean structure. (Author/BL)

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Do Females Expect to Fail on Piagetian Spatial Tasks?

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Abstract

Males have consistently been noted to perform better than females on Piagetian horizontality and verticality tasks. It is unclear, however, whether females are less competent than males or whether mediating variables influence females' performance. Using 42 male and 42 female college students as subjects, it was found that females performed more poorly on both tasks. It was also observed that females had lower expectancies for successful task performance and that individuals with lower expectancies for success tended to have lower task scores. When expectancies about performance were partialled out, the amount of horizontality variance explained by gender was reduced by 60% and the sex difference in performance was not significant. For verticality, while the sex difference remained significant with expectancies partialled out, there was a 40% reduction in the proportion of variance explained by gender. These findings support the view that expectancies mediate performance on these tasks. The sex difference in expectancies could not be accounted for by perceptions of the tasks as scientific/mathematical. Nor were ratings of the tasks as scientific related to actual task achievement. Performance on the horizontality and verticality tasks was moderately correlated for both sexes indicating that the two concepts do tap the same underlying Euclidean structure.

Relationship between Expectancies for Success
and Performance on Piagetian Spatial Tasks

The ability to use a Euclidean coordinate system has been identified by Piaget and Inhelder (1956) as being established by late childhood. Nevertheless, investigators have reported that adolescents and even adults fail to accurately represent horizontals and verticals of the physical world and that males significantly surpass females in performance on such tasks (Jamison & Signorella, 1980; Liben, 1978; Liben & Golbeck, 1980; Signorella & Jamison, 1978; Spradlin & Hensley, 1979; Thomas & Jamison, 1975). Moreover, performance on horizontal and vertical concept tasks should be highly correlated since both are presumed to involve the same Euclidean structure yet this seems to be true for males only (Liben, 1978), although it may depend upon how the tasks are presented (Liben & Golbeck, 1980; 1983).

Explanations for the observed sex differences in performance and correlation pattern can invoke either competence or utilization factors (Liben, 1978; Overton & Newman, 1982). Competence explanations assert that genetic, maturational, and/or experiential differences between males and females result in less mature, less integrated horizontality and verticality concepts in females. Utilization explanations assert that males and females have structurally similar Euclidean reference systems, i.e., competence, but that situational or organismic variables operate to interfere with the successful application of this knowledge.

The present investigation examined males' and females' expectancies about their performance on horizontality (water-level) and verticality (plumb-line) tasks in relation to their actual performance in order to determine if this factor is a utilization variable mediating observed sex

differences.

It has been reported that females have lower achievement expectancies than males. Such sex differences in expectancies have been found across a wide variety of ages and tasks and are more likely to be present if a task is unfamiliar (Crandall, 1969; Erkut, 1983; Frieze, 1975; 1978; Frieze, Fisher, Hanusa, McHugh, & Valle, 1978). A current model which takes into account research on sex differences in attribution patterns (Jackaway, 1974) suggests that females' low expectancies for success should lead to lower achievement behavior. According to this model, females begin with low generalized expectations. If task performance is successful, females tend to attribute the unexpected success to external, unstable causes such as luck so there is no reason to raise future expectations. If task performance is unsuccessful, the initial low expectations are confirmed and females tend to attribute the failure to a lack of ability. Thus, whether there is success or failure, the typical female pattern of attribution fosters low expectations for achievement. Since this model predicts poorer performance for females, it was hypothesized that the sex differences found for the water-level and plumb-line tasks may be at least partially due to females' low performance expectations.

A further feature of this investigation concerned the perceived nature of the spatial tasks. The water-level and plumb-line tasks have been described as being scientific or mathematical in nature and therefore subtly biased against females (Jamison & Signorella, 1978; Liben & Golbeck, 1980). There has been no attempt, however, to determine whether females themselves perceive the tasks as scientific/mathematical or whether such perceptions influence their performance on the tasks.

It was hypothesized that if there is an influence of this variable, then

females' ratings of the tasks as scientific should be negatively correlated with their task performance while no such relationship should occur for males. Further, females' expectancies for success and failure should be related to their perceptions of the tasks as scientific/mathematical. Their expectancies for failure should be positively correlated with science ratings. Such relationships in the data would not be anticipated for males.

Method

Subjects

Subjects were 42 male (M age = 20.8, SD = 2.3 months) and 42 female (M = 21.7, SD = 2.6 months) undergraduates enrolled in psychology classes in an urban university. The sample was heterogeneous with respect to race and socio-economic status. Participation in the study was voluntary.

Tasks

Overview. Testing was conducted by the first author in several mixed-sex groups ranging in size from two to twenty subjects. A testing session lasted approximately 20 minutes. The order of presentation of the horizontality and verticality tasks was counterbalanced. There is missing information for one male and one female subject. The male subject failed to rate his expectancy for success on the verticality task as well as his expectancy for failure on the task. The female subject failed to give a science rating on both the horizontality and verticality tasks. Since neither subject missed trials on the water-level or plumb-line tasks their data were included in the analyses.

Horizontality task. The concept of horizontality was assessed in a manner similar to Liben and Golbeck (1980). Subjects were shown a 6.5 x 10.2 cm rectangle resting upright (90^{o}) on a horizontal line. They were told that this was a sealed glass resting on a table top. A horizontal line indicated that the

glass was half-filled with water. Following this example, subjects were shown six randomly ordered 6.5 x 10.2 cm rectangles each resting on a horizontal line. The rectangles were tipped at 15°, 30°, 50°, 130°, 150°. and 165° where 0° was a rectangle resting on its long side, facing right. The subjects' task was to draw a line to indicate how the water would look in each of the tipped glasses. It was emphasized that each of the glasses was sealed so that water could not spill out. One point was assigned for each water-line drawn within 10° of the horizontal. Thus, scores could vary from 0-6.

Verticality task. The assessment of the concept of verticality was similar to that of horizontality. Subjects were shown a picture of a truck (6.5 x 10.2 cm rectangle with two wheels and a cab) containing a light bulb hanging from a cord suspended from the ceiling by a hook. The truck was shown facing right (0°) and resting on a horizontal line which subjects were told was a road. Following this example, subjects were shown six trucks inclined at 15°, 30°, 50°, 130°, 150°, and 165° with each truck resting on an oblique line representing a road. The inclined trucks were presented in random order. The subjects' task was to draw a line to indicate how the light bulb and cord would look in each truck. A circle was located at the midpoint of the ceiling in each truck as a starting point for the drawing. The truck was also said to be parked on the road to decrease the likelihood that subjects would incorrectly draw swinging cords. One point was assigned for each light cord drawn within 10° of the vertical. Thus scores could vary from 0-6.

Expectancies about Task Performance

Immediately after a task was described, subjects were asked to rate their expectancies for both success and failure on the tasks. They were asked: "Do you expect to do well (poorly) on the water glass (parked van) task?" They

responded using a 7-point scale with "1" being "very unlikely" to do well (poorly) and "7" being "very likely" to do well (poorly) on the task.

Perceptions of Tasks as Scientific

After both the water-level and the plumb-line tasks had been completed, subjects were asked to rate each task individually as to the extent to which they perceived it to be scientific/mathematical in nature. Ratings were on a 7-point scale with "1" being "not at all" scientific/ mathematical and "7" being "almost certainly" scientific/mathematical. No definition of "scientific/ mathematical" was provided by the experimenter.

Results

Task Performance

Independent sample *t*-tests revealed that there were significant sex differences in favor of males on both the horizontality task, t (82) = 2.42, p = .018 and on the verticality task, t (82) = 4.13, p = .001. To determine the size of the effects, point biserial correlations were computed. It was found that gender accounted for 6.7% of the variance in horizontality scores and 16.8% of the variance in verticality scores. Means and standard deviations on the tasks were: (a) horizontality: males, M = 4.17, SD = 1.92; females, M = 3.14, SD = 1.96 (b) verticality: males, M = 5.02, SD = 1.81; females, M = 3.29, SD = 2.04.

The correlations between horizontality and verticality task performance were significant and nearly identical for males and females: for males, r (40) = .52, p = .001; for females, r (40) = .56, p = .001.

Expectancies

Independent sample *t*-tests were employed to determine whether there were any significant sex differences in ratings of expectancy for either success or

failure on the water-level and plumb-line tasks. Using expectancy ratings for success as the dependent variable, males had a significantly greater expectancy of success on the verticality task, t (81) = 3.31, p = .001 but not on the horizontality task, t (82) = 1.67, p = .098. For both the horizontality task and the verticality task females expected to do significantly more poorly than males when expectancy ratings for failure were used as the dependent variable: for horizontality, t (82) = 2.64, p = .01; for verticality, t (81) = 2.65, p = .01. For the significant effects, point biserial correlations indicated that the proportion of variance in expectancy ratings explained by gender ranged from 7.6% to 11.8%. Means and standard deviations are presented in Table 1.

Insert Table 1 about here

To check on the reliability of expectancy ratings, subjects' expectancies for success were correlated with their expectancies for failure on a task. Correlations were high and significant for both sexes and ranged from -.66 to -.85 indicating adequate reliability.

Correlations between expectancy ratings about performance and actual scoreson the tasks were computed for each sex. The correlations are given in Table 2. Expectancies about horizontality task success and failure were significantly correlated with performance on the horizontality task for both males and females. The only significant correlate of performance on the verticality task was females' expectancy for success on that task.

Insert Table 2 about here

To address the question of whether the observed sex differences in expectancies mediate the sex differences in actual task performance, correlations between sex and task achievement were calculated and then expectancy ratings for success and failure were partialled out. The zero-order correlations between sex and task performance were (a) horizontality, r (82) = -.26, p = .018 and (b) verticality, r (82) = -.41, p = .001. With ratings of expectancies for success and failure partialled out the significant association between sex and horizontality performance dropped out (r (82) = -.16, p = .141) with expectancy differences accounting for 4% out of the 6.7% of variance explained by gender. Sex and verticality performance were still significantly associated (r (82) = -.32, p = .004), although expectancy differences accounted for 6.9% out of the 16.8% of the variance explained by gender.

Science Ratings

Independent sample t-tests using the ratings of the water-level and plumb-line tasks as scientific/mathematical in nature as dependent variables revealed no significant differences: for horizontality, t (81) = 1.80, p = .076; for verticality, t (81) = 1.93, p = .057. Means and standard deviations for the science ratings of the tasks were (a) horizontality: for males, M = 5.43, SD = 1.55; for females, M = 4.80, SD = 1.62 (b) verticality: for males, M = 5.29, SD = 1.74; for females, M = 4.59, SD = 1.55.

Correlations between the ratings of the tasks as scientific/mathematical and actual task scores were calculated for each sex. No significant correlations were noted for females: r (39) = -.02 for the horizontality task and r (39) = -.17 for the verticality task. For males, performance on the verticality task was significantly associated with its science rating, r (40) = .31, p = .043 but this was the not the case for horizontality task performance,

r (40) = -.21, p = .176.

Ratings of the tasks as scientific/mathematical and ratings of expectancies for success and failure on the tasks were also correlated. All correlations were non-significant and ranged from -.26 to .15.

Discussion

As hypothesized, sex differences in performance on the water-level and plumb-line tasks did occur with males performing better than females. The amount of variance explained by gender was 6.7% for horizontality and 16.8% for verticality. For purposes of comparison with a recent study that also used college students as subjects, the proportion of variance in horizontality and verticality scores explained by gender was computed using results reported by Liben and Golbeck (1983). Only results for the conditions where no examples and no rules about the horizontality of water and the verticality of plumb lines were given were included since these were the conditions similar to those of the present study. It was determined that, in these conditions, sex accounted for 16.2% (Study I) and 15.6% (Study II) of the variance in horizontality scores. For verticality, sex explained 19.2% (Study I) and 9.1% (Study II) of the variance. These percentages, including those for the present study, indicate that the effect size of the sex differences on these tasks is small.

Performance on the water-level and plumb-line tasks was found to be moderately correlated for both sexes suggesting the presence of integrated Euclidean structures. This result is consistent with Liben and Golbeck's (1983) findings.

In keeping with previous research (Crandall, 1969; Erkut, 1983; Frieze, 1975; 1978; Frieze et al., 1978), females were found to have lower expectancies for task success than males. It was also observed that expectancies were

related to achievement such that females with lower expectancies tended to perform more poorly on both tasks. (This was generally true for males also). This finding lends support to the performance implications of the low expectancy cycle of females (Jackaway, 1974), although a recent study by Erkut (1983) concerning college achievement did not.

The question may be raised as to whether this sex difference in expectancies is a mediator of females' horizontality/verticality competence or whether it merely represents realistic appraisals of ability based on past performance on similar tasks. The first interpretation is preferred here for three reasons.

First, recent research by Liben and Golbeck (1983) supports the viewpoint that sex differences on these spatial tasks are primarily due to performance factors and not to differences in competence. Liben and Golbeck's findings suggest that one reason females perform so poorly on these tasks is because they lack the relevant physical knowledge. They observed that when females were emphatically presented with rules about the invariant horizontality of water and the invariant verticality of plumb lines, their performance was similar to that of males. Research by Barsky and Lachman (1983) supports these findings. Liben and Golbeck argue that since females' performance markedly improves when they are presented with and attend to relevant information they must have the cognitive competence to assimilate this information. This argument is consistent with a Piagetian interpretation (Piaget & Inhelder, 1956).

Second, other investigators (e.g. Crandall, 1969; Erkut, 1983; Frieze et al., 1978) have found that males' and females' expectancies do not always reflect their past performance and that, when they do not, males tend to

overestimate their likelihood of success while females tend to underestimate theirs. These findings have been noted for a variety of tasks and age groups, including college students.

Third, there were no significant sex differences on the horizontality task when the effect of expectancies was controlled for, although the sex difference in verticality performance did not disappear. This discrepancy may have been due to the stronger zero-order correlation between sex and plumb-line task scores, however. Expectancies about verticality performance did lead to a 40% reduction in the amount of variance accounted for by gender. For the water-level task, taking expectancies into consideration resulted in a 60% drop in the amount of variance explained by gender. While these reductions are substantial, expectancies is apparently not the only factor related to sex differences in performance on these tasks.

While it seems reasonable that low expectancies influence females' utilization of competence, it must be recognized that the present study was correlational in nature. A further test of the hypothesis that differences in expectancies mediate performance on these spatial tasks would involve an experimental manipulation of expectancies through instruction or predetermined feedback.

The view that females' perceptions of the tasks as scientific/mathematical might negatively affect their spatial task performance was not supported. There was no relationship between horizontality and verticality scores and science ratings of the tasks. Nor was there a relationship between expectancies and perceptions of the tasks as scientific. These findings are consistent with those of Jamison and Signorella (1980) who found sex differences in favor of males for the water-level task whether its scientific nature was

exaggerated or played-down. Thus, there seems to be no basis for concluding that perceptions of the tasks as scientific/mathematical might also mediate sex differences in performance on these spatial tasks. There is evidence, however, that sex-role identity, as measured by the Bem Sex-Role Inventory, affects performance on the water-level task (Jamison & Signorella, 1980; Signorella & Jamison, 1978) such that females with a masculine sex-role identity perform better than females with a feminine sex-role identity.

Other factors such as cognitive style might also influence females' performance on these tasks. De Lisi (1983) has shown that the cognitive style variable of field dependence-independence affects the acquisition and utilization of the horizontality concept. Since adult males are more likely to be field independent than adult females and since these spatial tasks have strong field effects (De Lisi, 1983), sex differences in performance may be partially due to cognitive style differences.

A final issue concerns the determinants of sex differences in expectancies about performance on these spatial tasks. These differences cannot be accounted for by perceptions of the tasks as scientific/mathematical. More likely they are a product of traditional sex roles where males are stereotyped as being more intelligent, achieving, and competitive than females (Frieze, 1978). Recent studies suggest that such expectancy differences may be promoted by differential evaluative feedback that adults give to males and females and that this feedback is in keeping with traditional sex roles (Dweck & Bush, 1976; Dweck, Davidson, Nelson, & Enna, 1978). Findings by Erkut (1983) also indicate that sex-role orientation, as measured by the Bem Sex-Role Inventory, is related to sex differences in expectancies about achievement. Additional research examining factors that lead to sex differences in expectancies is clearly warranted.

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Table 1

Means and Standard Deviations for Expectancies for Success and Failure by Task and Sex

		Expectancy for success		Expectancy for failure	
	N	M	SD	M	SD
Horizontality					
Males	42	5.81	1.29	2.10	1.10
Females	42	5.36	1.19	2.81	1.37
Verticality					
Males	41	6.07	.88	2.05	1.14
Females	42	5.29	1.26	2.76	1.30

Note. Expectancy ratings range from 1-7.

Table 2

Correlations between Expectancies for Task Success and Failure and Actual Task Performance for Each Sex

		Horizontality Performance		Verticality Performance
Expectancy for success	N		N	
Males	42	.43***	41	.28
Females	42	.40**	42	.32*
Expectancy for failure				
Males	42	-.42***	41	-.17
Females	42	-.39**	42	-.17

*$p \leq .05$, **$p \leq .01$, ***$p \leq .005$.